

## WEED CONTROL IN KENAF (*Hibiscus cannabinus* L.) THROUGH SEQUENTIAL APPLICATION OF PRE- AND POST- EMERGENCE HERBICIDES

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### ABSTRACT

An experiment was conducted during April–September 2014 at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to evaluate the effect of some pre and post emergence herbicides on weed control, kenaf growth and yield. Fourteen treatment combinations formed by three pre-emergence herbicides (Panida, Prechlor and Manage), three post emergence herbicides (Quilop, Pyzero and Whip Super), hand weeding along with weedy check and weed free check were included in the study. The treatments were: T<sub>1</sub> = Weedy check, T<sub>2</sub> = Weed free check, T<sub>3</sub> = Panida + hand weeding (HW), T<sub>4</sub> = Prechlor + HW, T<sub>5</sub> = Manage + HW, T<sub>6</sub> = Panida + Pyzero, T<sub>7</sub> = Prechlor + Pyzero, T<sub>8</sub> = Manage + Pyzero, T<sub>9</sub> = Panida + Quilop, T<sub>10</sub> = Prechlor + Quilop, T<sub>11</sub> = Manage + Quilop, T<sub>12</sub> = Panida + Whip Super, T<sub>13</sub> = Prechlor + Whip Super and T<sub>14</sub> = Manage + Whip Super. The experiment was laid out in a randomized complete block (RCB) design with three replications. The result revealed that the treatment T<sub>13</sub> (Prechlor + Whip Super) showed best control of weeds as reflected by lowest weed density and weed dry matter. This treatment (Prechlor @ 1.0 L ha<sup>-1</sup> in combination with Whip Super @ 650 mL ha<sup>-1</sup>) gave the highest fibre and stick yields (3.55 and 7.59 t ha<sup>-1</sup>, respectively) due to improvement of yield attributing characters. The study concluded that weeds in kenaf could be effectively controlled and the highest kenaf yield could be obtained by the applying a pre-emergence herbicide Prechlor @ 1.0 L ha<sup>-1</sup> at 3 days after sowing (DAS) followed by the post emergence application of Whip Super @ 650 mL ha<sup>-1</sup> at 25 days after sowing (DAS).

**Keywords:** Weed density, weed dry matter, crop density, crop dry matter

### INTRODUCTION

Due to high market competition from synthetic materials, high input cost and unfavourable jute-rice price ratio, jute (*Corchorus spp.*) has been pushed to the marginal and less productive lands. At this situation, Kenaf (*Hibiscus cannabinus* L.) can be considered as an alternative crop for the marginal lands in place of jute due to high capacity of kenaf for its tolerance to biotic and abiotic stresses.

Weed competition may lead to a moderate to heavy yield reductions in kenaf. Kurtz and Neill (1990) reported an 85% yield reduction in kenaf for weed competition. Kenaf is a crop and no such survey report is yet available. However, weed control is an important task in obtaining optimum yield of kenaf. Hand weeding by *nirani* is the traditional and most effective method of weed control. This method is very laborious, time consuming and expensive. During the peak period, the unavailability of labour becomes a serious problem for weed management. In this situation, chemical weed control could be an alternative method for weed control in kenaf. This practice is now gaining popularity all over the world because of its miraculous positive results in crop production and less cost investment compared to traditional method of weeding. A number of research works on chemical weed control in jute have been reported but research work on herbicidal weed control in kenaf is highly scarce. So, this piece of research work was initiated to find out the effective herbicides that would control weed effectively and increase yield of kenaf.

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## **MATERIALS AND METHODS**

### **Site and soil**

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh to evaluate the effect of herbicides on weed infestation and growth of kenaf. The site was a medium highland with moderate drainage condition and is located at 24° 75' N latitude, 90° 50' E longitude and 18 m altitude (above the sea level). The soil of the experimental land belongs to non-calcareous dark grey floodplain soil type under the Sonatola series of the Old Brahmaputra Alluvial Tract and Old Brahmaputra Floodplain Agroecological Zone (AEZ 9). The soil was silt-loam in texture having a pH value of 6.52 and organic matter content of 1.67%. The soil contained 0.1% total nitrogen, 13.90 ppm available phosphorus, 26.0% available sulphur and 0.14 meq exchangeable potassium 100 g<sup>-1</sup> soil.

### **Experimental treatments and Design**

The experiment included 14 treatment combinations comprising three pre-emergence herbicides (Panida, Prechlor and Manage), three post emergence herbicides (Quilop, Pyzero and Whip Super), hand weeding (HW), weed free check and weedy check. The treatments were: (i) weedy check (T<sub>1</sub>), (ii) weed free check (T<sub>2</sub>), (iii) Panida + HW (T<sub>3</sub>), (iv) Prechlor + HW (T<sub>4</sub>), (v) Manage + HW (T<sub>5</sub>), (vi) Panida + Pyzero (T<sub>6</sub>), (vii) Prechlor + Pyzero (T<sub>7</sub>), (viii) Manage + Pyzero (T<sub>8</sub>), (ix) Panida + Quilop (T<sub>9</sub>), (x) Prechlor + Quilop (T<sub>10</sub>), (xi) Manage + Quilop (T<sub>11</sub>), (xii) Panida + Whip super (T<sub>12</sub>), (xiii) Prechlor + Whip super (T<sub>13</sub>) and (xiv) Manage + Whip super (T<sub>14</sub>). The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. There were 42 plots and the size of each unit plot was 12 m<sup>2</sup> (4 m × 3 m).

### **Crop Husbandry**

Seed of kenaf variety HC-95 was sown on 25 April 2014 by continuous dropping of seeds in 25 cm apart rows at a depth of 3-4 cm using 12 kg seed ha<sup>-1</sup>. The land was fertilized with urea, triple super phosphate (TSP) and muriate of potash (MoP) @ 50, 20 and 40 kg ha<sup>-1</sup>, respectively. All the fertilizers except urea were applied at the time of final land preparation and urea was top dressed in two equal splits at 30 and 45 days after sowing (DAS). The crop was thinned out by uprooting kenaf seedlings at 15 and 30 DAS. No major insect pest and disease infestations were observed in the experimental crops. Pre-emergence herbicides Panida, Prechlor and Manage were applied at 3 DAS at the rate of 2.5 L ha<sup>-1</sup>, 1.0 L ha<sup>-1</sup> and 0.21 kg ha<sup>-1</sup>, respectively. Early post emergence herbicides Pyzero, Quilop and Whip super were applied at 25 DAS at the rate of 750, 650 and 650 mL ha<sup>-1</sup>, respectively.

### **Harvesting and processing**

The crop was hand harvested at maturity on 25 September 2014. Five plants were randomly taken from each plot to record the yield contributing characters of kenaf. Harvested plants were tied in small bundles and heaped for one week for shedding of leaves. After shedding of leaves, the kenaf bundles were placed plot-wise in pond water for retting. The retting process was completed by 20 days of placement in pond water. After proper retting the fibres were extracted by stripping and washed thoroughly in water. The extracted fibres were dried in the sun plot-wise on bamboo bars. After drying the fibre was weighed to get the fibre yield. The sun-dried sticks were weighed to record the yield of sticks.

### **Data recording**

Data on weed density and dry matter were recorded by taking weeds from 0.25 × 0.25 m area at 20, 40, 60 and 95 DAS. The density was expressed in no. m<sup>-2</sup>. The collected weeds were dried in an

electrical oven for 72 hours maintaining a constant temperature of 70 °C and the dry matter of weed was expressed as g m<sup>-2</sup>.

### Growth and yield parameters of crop

Leaf chlorophyll content (SPAD value), plant height (cm), plant density (No. m<sup>-2</sup>), plant dry matter (g plant<sup>-1</sup>), plant diameter (base, middle and top), stick diameter (base, middle and top), Fresh plant, stick and bark weight (g plant<sup>-1</sup>), dry bark and stick weight (g plant<sup>-1</sup>), total fibre yield (t ha<sup>-1</sup>) and stick yield (t ha<sup>-1</sup>) were recorded. SPAD value was recorded at 60 DAS with portable SPAD meter (SPAD 502, Minolta, Japan). Plant height and total dry matter were recorded at 60 and 150 DAS. All other characters were recorded at 150 DAS.

### Statistical analysis

The data were compiled and tabulated in proper form and subjected to statistical analysis. Analysis of variance was done with the help of computer package MSTAT-C program. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test (DMRT).

## RESULTS AND DISCUSSION

### Infested weed species in experimental field

Sixteen different weed species belonging to six families were found to infest the experimental field (Table 1). Among the infesting weed species, 6, 4, 2, 2, 1 and 1 species belonged to Graminaea, Cyperaceae, Compositae, Commelinaceae, Leguminosae and Polygonaceae, respectively. The most important weed species found in kenaf field were *Echinochloa crusgalli*, *Echinochloa colonum*, *Paspalum scrobiculatum*, *Cynodon dactylon*, *Paspalum commersoni*, *Fimbristylis miliacea*, *Cyperus difformis*, *Cyperus rotundus*, *Fimbristylis diphylla*, *Xanthium italicum*, *Eclipta alba*, *Cyanotis axillaris*, *Commelina benghalensis*, *Persicaria orientalis* and *Mimosa invisa*.

**Table 1. Weed species infesting in the kenaf field under weedy plots**

Sl. No	Local name	Scientific name	Family	Morpho-logical type	Life cycle
1.	Boro shama	<i>Echinochloa crusgalli</i> L.	Gramineae	Grass	Annual
2.	Khude shama	<i>Echinochloa colonum</i> L.	Gramineae	Grass	Annual
3.	Angta	<i>Paspalum scrobiculatum</i> L.	Gramineae	Grass	Perennial
4.	Angulee ghash	<i>Digitaria sanguinalis</i> L.	Gramineae	Grass	Perennial
5.	Durba	<i>Cynodon dactylon</i> (L.) Pers.	Gramineae	Grass	Perennial
6.	Gaicha/Moina	<i>Paspalum commersonii</i> Lam.	Gramineae	Grass	Annual
7.	Joina	<i>Fimbristylis miliacea</i> Linn.	Cyperaceae	Sedge	Annual
8.	Sabuj nakful	<i>Cyperus difformis</i> L.	Cyperaceae	Sedge	Perennial
9.	Mutha	<i>Cyperus rotundus</i> L.	Cyperaceae	Grass	Perennial
10.	Matichech	<i>Fimbristylis diphylla</i> Retz.	Cyperaceae	Sedge	Annual
11.	Ghagra	<i>Xanthium italicum</i> Moretti	Compositae	Broad leaf	Annual
12.	Keshuty	<i>Eclipta alba</i> L.	Compositae	Grass	Annual
13.	Kanainala	<i>Cyanotis axillaris</i> L.	Commelinaceae	Grass	Annual
14.	Kanaibashi	<i>Commelina benghalensis</i> L.	Commelinaceae	Grass	Annual
15.	Panimarich	<i>Persicaria orientalis</i> L.	Polygonaceae	Grass	Annual
16.	Lazzabati	<i>Mimosa invisa</i> Mart.	Leguminosae	Sedge	Perennial

### Weed density and dry matter

The herbicide treatment had significant effects on weed density as found at 20, 40, 60 and 95 DAS. At 20 DAS, the highest weed density (81 m<sup>-2</sup>) was found in no weeding plots (Table 2) and the lowest weed density (20 m<sup>-2</sup>) was observed in plots treated with Manage @ 0.21 kg

ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> and Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. The occurrence of lowest total weed density in these treatments might be due to effective control of weed seed germination in early stage of crop growth by pre-emergence Manage and Prechlor herbicides at 20 DAS. At 40 DAS, maximum weed density (90.67 m<sup>-2</sup>) was found in unweeded plots and the minimum weed density (23.33 m<sup>-2</sup>) was obtained from Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup>. This treatment combination also gave the similar result at 60 DAS. At 60 DAS, highest weed density (97 m<sup>-2</sup>) was found in no weeding plot and the lowest weed density (24.00 m<sup>-2</sup>) was observed in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650mL ha<sup>-1</sup> treated plots. Similarly at 95 DAS, maximum weed density (55.33 m<sup>-2</sup>) was found in no weeding plot and the minimum weed population was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. In a study, Kumar et al. (2013) reported that Prechlor 500 EC @ 0.83 to 0.90 kg ha<sup>-1</sup> killed almost all grass weeds. Many studies reported that Post emergence application of Whip super 9 EC @ 75 g ha<sup>-1</sup> at 21 days after sowing effectively controlled the grass weeds (Ghorai *et al.*, 2008; Hossain, 2013; Ghorai *et al.*, 2013). Faruq (2013) also reported that application of Prechlor 500 EC @ 1.5 L ha<sup>-1</sup> showed the best performance in reducing weed density.

### Weed dry matter

Weed dry matter collected at 20, 40, 60 and 95 DAS was affected by herbicide treatments (Table 2).

**Table 2. Weed density and dry matter at 20, 40, 60 and 95 days after sowing as influenced by herbicide treatments**

Weed control treatment	Weed density (number m <sup>-2</sup> )				Weed dry matter (g m <sup>-2</sup> )			
	20 DAS	40 DAS	60 DAS	95 DAS	20 DAS	40 DAS	60 DAS	95 DAS
T <sub>1</sub>	81.00a	90.67a	97.00a	55.33a	18.45a	22.60a	24.05a	15.54a
T <sub>2</sub>	-	-	-	-	-	-	-	-
T <sub>3</sub>	30.33cd	32.67c	42.33c	27.33c	4.82ef	11.12bc	12.76bc	9.56cd
T <sub>4</sub>	24.00fg	27.00d	35.00ef	26.00cd	3.12g	10.75bc	13.12bc	9.22d
T <sub>5</sub>	28.67de	33.00c	38.33d	26.00cd	4.25f	10.98bc	13.95b	9.25d
T <sub>6</sub>	32.33bc	34.33bc	37.00de	27.00cd	5.28de	10.12bc	12.01c	9.85bcd
T <sub>7</sub>	21.00gh	23.67e	35.00ef	27.67c	6.13cd	11.38bc	12.25c	10.25bc
T <sub>8</sub>	30.00cd	34.00bc	38.00d	30.00bc	7.20b	12.52b	12.56bc	10.54b
T <sub>9</sub>	33.33bc	35.33bc	37.00de	28.00bc	7.35b	10.98bc	12.50bc	10.24bc
T <sub>10</sub>	25.33ef	27.67d	34.00f	23.00de	5.11ef	9.42c	10.32d	9.12d
T <sub>11</sub>	27.00def	35.00bc	46.00b	32.00b	6.25c	9.85c	11.98c	10.26bc
T <sub>12</sub>	34.33b	36.67b	45.00bc	28.00bc	4.28f	10.25bc	10.23d	9.53cd
T <sub>13</sub>	20.00h	23.33e	24.00g	18.00f	2.94g	4.56d	7.32e	5.95e
T <sub>14</sub>	20.00h	24.67de	27.00def	21.33ef	2.98g	4.68d	8.25e	6.23e
LS	**	**	**	**	**	**	**	**
CV(%)	6.40	5.56	3.80	8.96	8.43	10.63	4.47	9.95

In a column, figures with similar letters are not significant at 5% level, \*\* = significant at 1% level, LS = level of significance, CV = coefficient of variation, Weed control treatments: (i) weedy check (T<sub>1</sub>), (ii) weed free check (T<sub>2</sub>), (iii) Panida + HW (T<sub>3</sub>), (iv) Prechlor + HW (T<sub>4</sub>), (v) Manage + HW (T<sub>5</sub>), (vi) Panida + Pyzero (T<sub>6</sub>), (vii) Prechlor + Pyzero (T<sub>7</sub>), (viii) Manage + Pyzero (T<sub>8</sub>), (ix) Panida + Quilop (T<sub>9</sub>), (x) Prechlor + Quilop (T<sub>10</sub>), (xi) Manage + Quilop (T<sub>11</sub>), (xii) Panida + Whip super (T<sub>12</sub>), (xiii) Prechlor + Whip super (T<sub>13</sub>) and (xiv) Manage + Whip super (T<sub>14</sub>).

The highest dry weight of weed (18.45 g m<sup>-2</sup>) was found in no weedy check plots and the lowest value (2.94 g m<sup>-2</sup>) was observed in Prechlor @ 1.0 L ha<sup>-1</sup> + whip super @ 650 mL ha<sup>-1</sup> treated plots at 20 DAS. At 40 DAS, maximum dry weight of weed (22.60 g m<sup>-2</sup>) was found in no weeding and the minimum dry weight of weed (4.56 g m<sup>-2</sup>) was obtained from Prechlor @ 1.0 L ha<sup>-1</sup> + whip super @ 650 mL ha<sup>-1</sup>. At 60 DAS, highest dry weight of weed (24.04 g m<sup>-2</sup>) was found in no weeding and

the lowest dry weight of weed ( $7.32 \text{ g m}^{-2}$ ) was observed in Prechlor @  $1.0 \text{ L ha}^{-1}$  + whip super @  $650 \text{ mL ha}^{-1}$  treated plots. At 95 DAS, maximum dry weight of weed ( $15.54 \text{ g m}^{-2}$ ) was found in no weeding plots and the minimum ( $5.95 \text{ g m}^{-2}$ ) was found in Prechlor @  $1.0 \text{ L ha}^{-1}$  + whip super @  $650 \text{ mL ha}^{-1}$  treated plots. The result revealed that herbicide application killed weeds and contributed to reduction in weed dry matter. Kumar *et al.* (2013) reported that Prechlor 500 EC @  $0.83$  to  $0.90 \text{ kg ha}^{-1}$  killed almost all grass weeds. Post emergence application of whip super 9 EC @  $75 \text{ g ha}^{-1}$  at 21 DAS effectively controlled the grass weeds (Sarkar, 2006). Faruq (2013) also reported that application Prechlor 500 EC @  $1.5 \text{ L ha}^{-1}$  showed the best performance in reducing weed density. As a result, dry weight of weeds was the lowest in Prechlor 500 EC @  $1.04 \text{ L ha}^{-1}$  along with whip super 9 EC @  $1.42 \text{ L ha}^{-1}$  treated plots.

### Plant density, chlorophyll content and dry matter of kenaf

#### Plant density

Significant variation was observed in plant number of kenaf due to different weed control treatments (Table 3). The highest number of plant ( $80.00 \text{ m}^{-2}$ ) was obtained from Prechlor @  $1.0 \text{ L ha}^{-1}$  + Quilop @  $650 \text{ mL ha}^{-1}$ , Prechlor @  $1.0 \text{ L ha}^{-1}$  + Whipsuper @  $650 \text{ mL ha}^{-1}$  and Prechlor @  $1.0 \text{ L ha}^{-1}$  + Quilop @  $650 \text{ mL ha}^{-1}$  treatments. The second highest plant number ( $78 \text{ m}^{-2}$ ) was produced by Panida @  $2.50 \text{ L ha}^{-1}$  + Pyzero @  $750 \text{ mL ha}^{-1}$  treated plots. The lowest plant number was observed in no weeding treatment. Weeds offered high competition with crop in no weeding plots than the herbicide treated plots that ultimately reduced the number of plants. But different herbicides reduced weed population and thereby decreased weed crop competition during entire growth stage.

**Table 3. Plant density, plant height, total dry matter and leaf chlorophyll content of kenaf at 60 DAS in response to herbicide treatments**

Weed control treatment	Plant density (no. $\text{m}^{-2}$ )	Plant height (cm)	Dry matter of crop ( $\text{g m}^{-2}$ )	Leaf chlorophyll content (ppm)
No weeding	51.00 e	30.28 c	352.30 i	50.02 cde
Weed free	76.00b cd	50.03 a	628.80 e	50.50 bcd
Panida + HW	77.00 bc	49.37 a	590.40 f	47.23 f
Prechlor + HW	77.00 bc	50.22 a	647.70 cd	49.13 def
Manage + HW	75.00 cd	48.85 a	846.20 g	44.25 g
Panida + Pyzero	78.00 ab	50.03 a	642.00 de	49.13 def
Prechlor + Pyzero	76.00b cd	49.70 a	599.50 f	48.23 ef
Manage + Pyzero	74.25 d	48.85 a	540.20 g	43.53 g
Panida + Quilop	77.00 bc	50.03 a	642.10 de	48.25 ef
Prechlor + Quilop	80.00 a	50.88 a	656.20 c	52.23 ab
Manage + Quilop	75.00 cd	48.85 a	541.00 g	42.53 gh
Panida + Whip Super	80.00 a	51.22 a	680.60 b	52.00 abc
Prechlor + Whip Super	80.00 a	51.22 a	717.10 a	52.50 a
Manage + Whip Super	74.25 d	44.82 b	520.20 h	41.53 h
LS	**	**	**	**
CV(%)	3.22	6.12	1.24	6.00

In a column, the values having common letter(s) do not differ significantly. \*\* = Significant at 1% level of probability; CV = Co-efficient of variation; Weed control treatments: (i) weedy check ( $T_1$ ), (ii) weed free check ( $T_2$ ), (iii) Panida + HW ( $T_3$ ), (iv) Prechlor + HW ( $T_4$ ), (v) Manage + HW ( $T_5$ ), (vi) Panida + Pyzero ( $T_6$ ), (vii) Prechlor + Pyzero ( $T_7$ ), (viii) Manage + Pyzero ( $T_8$ ), (ix) Panida + Quilop ( $T_9$ ), (x) Prechlor + Quilop ( $T_{10}$ ), (xi) Manage + Quilop ( $T_{11}$ ), (xii) Panida + Whip super ( $T_{12}$ ), (xiii) Prechlor + Whip super ( $T_{13}$ ) and (xiv) Manage + Whip super ( $T_{14}$ ).

#### Plant height

Significant ( $p < 0.01$ ) variation was observed in plant height due to different weed control treatments (Table 3 and 4). At 60 DAS, tallest plant height ( $51.22 \text{ cm}$ ) was found in the Panida @  $2.50 \text{ L ha}^{-1}$  + Whip Super @  $650 \text{ mL ha}^{-1}$  treated plot. The second highest plant height ( $50.88 \text{ cm}$ ) was produced by Prechlor

@ 1.0 L ha<sup>-1</sup> + Quilop @ 650 mL ha<sup>-1</sup>. The lowest plant height was observed in no weeding treatment. At 150 DAS, significant (p<0.01) variation was also observed in respect of plant height of kenaf due to different weed control treatments. The maximum plant height (420 cm plant<sup>-1</sup>) was found by the Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> followed by Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> (333 cm plant<sup>-1</sup>). The lowest plant height (221 cm) was observed in no weeding treatment. Weed competition was severe in weedy check condition and thus plant height of kenaf was reduced. Similar results also were reported by Borgohain *et al.* (1990) that plant height was significantly reduced by heavy infestation of weeds. On the other hand, in different weed control methods through the crop growth period competition between weed and kenaf was less therefore plant height was increased.

**Table 4. Plant height and diameter of plant and stick at base, middle, and top of kenaf plant at 150 days after sowing in response to herbicide treatments**

Weed control treatment	Plant height (cm)	Plant base diameter (mm)	Plant middle diameter (mm)	Plant top diameter (mm)	Stick base diameter (mm)	Stick middle diameter (mm)	Stick top diameter (mm)
T <sub>1</sub>	221 d	14.02 e	9.37 f	7.02 j	11.53 g	9.24 c	5.21 b
T <sub>2</sub>	313 b	15.45 cd	11.29 de	7.49 i	15.11 cd	11.20 b	5.86 ab
T <sub>3</sub>	312 b	14.85 de	11.61 cd	8.13 f	13.42 ef	11.60 b	6.32 ab
T <sub>4</sub>	323 ab	16.36 ab	12.23 abc	8.72 c	13.52 ef	11.22 b	6.69 ab
T <sub>5</sub>	316 b	15.98 abc	11.69 bcd	7.98 g	12.98 f	10.12 bc	5.82 ab
T <sub>6</sub>	315 b	16.54 ab	12.51 ab	8.39 d	14.83 d	10.12 bc	6.66 ab
T <sub>7</sub>	312 b	16.55 ab	11.66 bcd	8.28 e	15.80 bc	11.22 b	6.49 ab
T <sub>8</sub>	297 c	15.94 abc	10.65 e	8.78 b	13.01 f	10.10 bc	5.75 ab
T <sub>9</sub>	309 bc	16.17 abc	11.88 a-d	8.16 f	14.23 de	11.45 b	6.39 ab
T <sub>10</sub>	309 bc	15.75 bc	12.03 a-d	8.32 e	15.80 bc	11.15 bc	6.62 ab
T <sub>11</sub>	315 b	15.79 bc	11.38 cde	8.38 d	13.02 f	10.12 bc	6.19 ab
T <sub>12</sub>	420 ab	16.55 ab	11.48 cde	8.78 b	16.16 b	16.55 a	6.61 ab
T <sub>13</sub>	333 a	16.68 a	12.73 a	8.98 a	18.52 a	16.68 a	6.93 a
T <sub>14</sub>	312 b	15.94 abc	11.55 cd	7.81 h	11.80 g	10.32 bc	6.29 ab
LS	**	NS	NS	NS	**	**	NS
CV(%)	3.59	13.74	13.20	12.61	9.37	10.70	14.95

In a column, figures with similar letters are not significant at 5% level, \*\* = significant at 1% level, NS = Not significant, LS = level of significance, CV = coefficient of variation, Weed control treatments: (i) weedy check (T<sub>1</sub>), (ii) weed free check (T<sub>2</sub>), (iii) Panida + HW (T<sub>3</sub>), (iv) Prechlor + HW (T<sub>4</sub>), (v) Manage + HW (T<sub>5</sub>), (vi) Panida + Pyzero (T<sub>6</sub>), (vii) Prechlor + Pyzero (T<sub>7</sub>), (viii) Manage + Pyzero (T<sub>8</sub>), (ix) Panida + Quilop (T<sub>9</sub>), (x) Prechlor + Quilop (T<sub>10</sub>), (xi) Manage + Quilop (T<sub>11</sub>), (xii) Panida + Whip super (T<sub>12</sub>), (xiii) Prechlor + Whip super (T<sub>13</sub>) and (xiv) Manage + Whip super (T<sub>14</sub>).

### Dry matter of crop

Significant variation was observed in dry weight of plant due to different weed control treatments (Table 3). The highest dry weight of plant (717.10 g) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup>. The second highest dry weight of plant (680.60 g) was produced by Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treatment. The lowest dry weight of plant (352.30 g) was observed in no weeding treatment. This was due to severe competition of weed for moisture, space, light and nutrients between weed and crop throughout the crop season. As a result, minimum dry weight of plant was observed in no weeding treatment.

### Leaf chlorophyll content

Leaf chlorophyll contents (SPAD value) ranged from 41.53 to 52.50 ppm in kenaf leaf in different weed management practices (Table 3). Maximum SPAD value (52.53 ppm) was observed in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> and the lowest SPAD value (41.530 ppm) was found in Manage @ 0.21 kg ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup>. From these results, it may be concluded that

plant was not suffered with all treatments throughout the growing season of kenaf except Manage @ 0.21 kg ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup>. Malan (2011) reported that the S-dimethenamid and Fluometuron/Prometryn created injury to the kenaf seedlings. Saeed also reported that herbicides are sprayed as per recommendations of the manufacturer their residual effect can be kept to the minimum (Saeed, 1992).

#### ***Plant diameter (base, middle and top)***

Plant diameter (base, middle and top) per plant at 150 DAS was significantly affected by weed control treatments (Table 4). The highest base diameter of plant (16.68 mm plant<sup>-1</sup>) was found in plots treated with Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> followed by Prechlor @ 1.0 L ha<sup>-1</sup> + one hand weeding, Panida @ 2.50 l ha<sup>-1</sup> and Prechlor @ 1.0 L ha<sup>-1</sup> treatments. The lowest plant base diameter (14.02 mm plant<sup>-1</sup>) was observed in no weeding treated plots at 150 DAS. Among the weed management practices, Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> helped to create good growth of kenaf from germination to 150 DAS. The highest middle diameter of plant (12.73 mm plant<sup>-1</sup>) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots followed by Panida @ 2.50 L ha<sup>-1</sup> + Pyzero @ 750 mL ha<sup>-1</sup> treatments. The third highest plant middle diameter (12.23 mm plant<sup>-1</sup>) was obtained from Prechlor @ 1.0 L ha<sup>-1</sup> + one hand weeding. The lowest plant middle diameter was found in no weeding method. The effect of weed control treatment on top diameter of plant was not statistically significant. The highest top diameter of plant (8.98 mm plant<sup>-1</sup>) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. The lowest plant top diameter (7.02 mm plant<sup>-1</sup>) was found in no weeding method. The results are in conformity with those reported by Gupta (1984). The increase in diameter in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots might be due to effective control of weed throughout the growing season of crop.

#### ***Stick diameter (base, middle and top)***

Effect of weed management practices on stick diameter (base, middle and top) of kenaf was found significant at 150 DAS (Table 4). The highest base diameter of stick (18.52 mm plant<sup>-1</sup>) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650mL ha<sup>-1</sup> method and the lowest plant base diameter (11.53 mm plant<sup>-1</sup>) was observed in no weeding treated plots at 150 DAS. Among the weed management practices, Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> helped to create good growth of kenaf up to 150 DAS. This might be due to effective control of weed growth and germination of weed by Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> from germination to 150 DAS. The highest middle diameter of stick (16.68 mm plant<sup>-1</sup>) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> followed by Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. The second highest stick middle diameter (11.60 mm plant<sup>-1</sup>) was obtained from Panida @ 2.50 L ha<sup>-1</sup> + one hand weeding. The lowest stick middle diameter (9.24 mm plant<sup>-1</sup>) was found in no weeding method. Maximum top diameter of stick (6.93 mm plant<sup>-1</sup>) was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> followed by all other treatments except no weeding treated plots. The second highest stick middle diameter (6.69 mm plant<sup>-1</sup>) was obtained from Prechlor @ 1.0 L ha<sup>-1</sup> + one hand weeding treated plots. The lowest stick middle diameter (9.24 mm plant<sup>-1</sup>) was found in no weeding method. This finding was similar to that of Ray et al. (1988).

#### ***Fresh weight of plants of kenaf***

Fresh weight of plant, stick and bark were affected by weed management treatment (Table 5). Maximum fresh plant weight was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. Minimum fresh plant weight was obtained from weedy control plots. Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated produced the highest fresh stick weight (138.70 g plant<sup>-1</sup>). The lowest fresh stick weight was observed in weedy check plots. In respect of fresh bark weight,

maximum weight was found in Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plot followed by weed free treated plots.

**Table 5. Effect of herbicide treatments on fresh weight of plant, stick and bark and dry weight of bark and stick of kenaf at harvest stage**

Treatments	Plant fresh weight (g plant <sup>-1</sup> )	Stick fresh weight (g plant <sup>-1</sup> )	Bark fresh weight (g plant <sup>-1</sup> )	Bark dry weight (g plant <sup>-1</sup> )	Stick dry weight (g plant <sup>-1</sup> )
No weeding	220 i	85.67g	70.00h	7.22c	30.00g
Weed free	261 h	104.00f	94.00ab	11.07b	37.33f
Panida + HW	269 g	114.70cd	85.67e	10.00b	48.22cde
Prechlor + HW	256 h	103.00f	92.63abc	10.43b	52.00cd
Manage + HW	262 h	106.50ef	90.33cd	10.53b	44.00e
Panida + Pyzero	256 h	107.70ef	93.73ab	10.00b	52.67bc
Prechlor + Pyzero	296 c	116.20c	92.20bc	10.06b	57.00ab
Manage + Pyzero	283 de	104.00f	76.67g	9.74b	44.67e
Panida + Quilop	298 c	113.70cd	80.00f	9.39b	48.00cde
Prechlor + Quilop	275 f	106.00ef	88.33de	9.73b	51.67cd
Manage + Quilop	278 ef	110.30de	92.33abc	10.67b	47.33de
Panida + Whip Super	313 b	123.00b	79.66fg	11.00b	58.00a
Prechlor + Whip Super	340 a	138.70a	95.32a	14.00a	60.00a
Manage + Whip Super	288 d	118.30bc	79.67fg	9.89b	48.00cde
LS	**	**	**	*	**
CV(%)	2.90	3.94	4.93	15.63	5.32

In a column, the values having common letter(s) do not differ significantly. \* = Significant at 5% level of probability \*\* = Significant at 1% level of probability; CV = Co-efficient of variation; HW = Hand weeding

### ***Bark and stick fresh and dry weight of kenaf***

Significant variation was observed in dry bark and stick weight of kenaf due to different weed control treatments (Table 5). Maximum dry bark weight (14.00 g plant<sup>-1</sup>) was produced by the Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> followed by Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treatments. The second highest dry bark weight (11.07 g plant<sup>-1</sup>) was produced by weed free treatment. The lowest dry bark weight (7.22 g plant<sup>-1</sup>) was observed in no weeding treatment. Highest dry stick weight (60.33 g plant<sup>-1</sup>) was produced by the Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treatment. The second highest dry stick weight (58.00 g plant<sup>-1</sup>) was produced by Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. The lowest dry stick weight (30.00 g plant<sup>-1</sup>) was observed in no weeding treatment. The severe competition of weed for moisture, space, light and nutrients with crop caused to reduce dry stick and bark weights.

### ***Fibre yield of kenaf***

Weed control treatment exerted significant influence (p<0.01) on total fibre yield of kenaf (Figure 1). The highest fibre yield (3.55 t ha<sup>-1</sup>) was produced by the Prechlor @ 1.0 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treatment. The second highest fibre yield (3.15 t ha<sup>-1</sup>) was noted in Panida @ 2.50 L ha<sup>-1</sup> + Whip super @ 650 mL ha<sup>-1</sup> treated plots. The lowest total fibre yield was observed in no weeding treatment. In weedy plots, severe competition for moisture, space, light and nutrients between weed and crop occurred and eventually fibre yield was reduced. In a study it was noted that application of preemergence of Pretichlor 500 EC @ 1.04 L ha<sup>-1</sup> and Panida 33 EC @ 2.08 L ha<sup>-1</sup> in combination with post emergence herbicides Fenaxopro-p-ethyl not only controlled the grass weeds but also resulted in higher fibre yield (Sarkar, 2006). Similar findings were also reported by (Barman, 1998; Rajput, 2000).

### Stick yield of kenaf

Weed control treatment had significant ( $p < 0.01$ ) effect on stick of kenaf (Figure 1). The highest stick yield ( $7.59 \text{ t ha}^{-1}$ ) was produced by the Prechlor @  $1.0 \text{ L ha}^{-1}$  + Whip super @  $650 \text{ mL ha}^{-1}$  followed by Manage @  $0.21 \text{ kg ha}^{-1}$  + Quilop @  $650 \text{ mL ha}^{-1}$ , Manage @  $0.21 \text{ kg ha}^{-1}$  + whip super @  $650 \text{ mL ha}^{-1}$ . The lowest stick yield ( $4.65 \text{ t ha}^{-1}$ ) was observed in no weeding treatment. Severe competition of weed with crops for moisture, space, light and nutrients eventually reduced the stick yield. Ashraf *et al.* (2006) reported that herbicide applied plots performed better than weedy plot in respect of crop yield. Similar findings were also reported by Mishra and Nayak (1995).

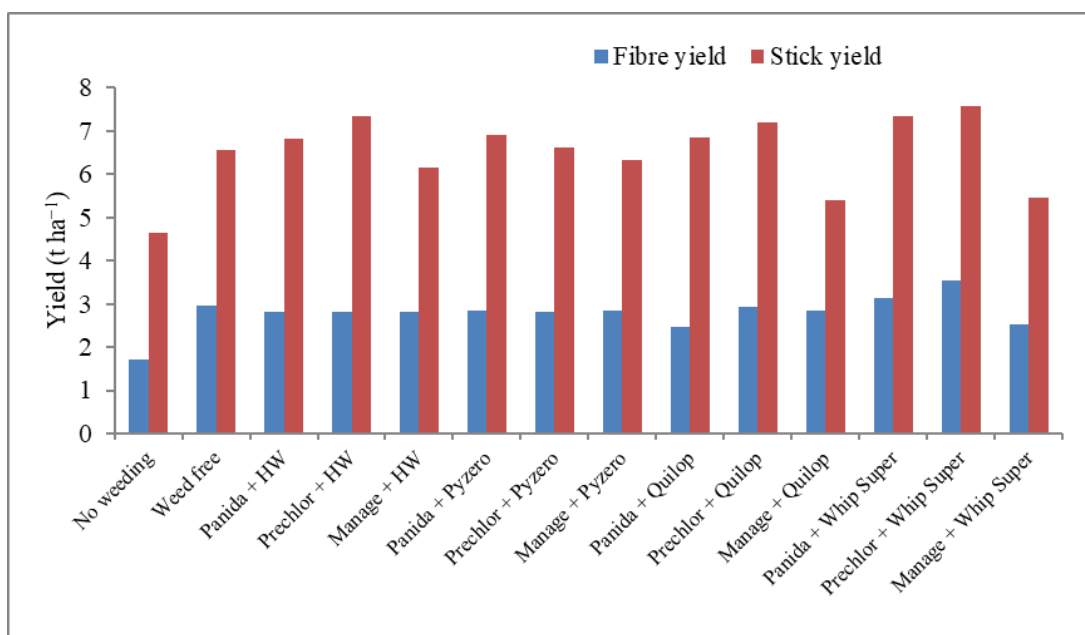


Fig. 1. Effect of herbicide treatments on fibre and stick yields of kenaf.

### CONCLUSION

Herbicide is a low-cost technology that help effective weed control and achieving higher yield of kenaf. Three pre-emergence herbicides like Panida, Prechlor, Manage and three post-emergence herbicides like Quilop, Pyzeroo and Whip super were included in the study. The result of the study revealed that preemergence application of Prechlor @  $1.0 \text{ L ha}^{-1}$  in combination with post-emergence application of Whip Super @  $650 \text{ mL ha}^{-1}$  gave the best weed control and produced the highest fibre and stick yields ( $3.55$  and  $7.59 \text{ t ha}^{-1}$ , respectively), due to improvement of yield attributing characters. The study concluded that application of pre-emergence herbicide Prechlor @  $1.0 \text{ L ha}^{-1}$  at 3 days after sowing (DAS) and the post emergence herbicide Whip Super @  $650 \text{ mL ha}^{-1}$  at 25 days after sowing (DAS) could be considered as an effective weed control measure for kenaf.

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